ATMOSPHERIC/OCEAN INTERACTION STUDIES
PE 0601153N (NRL BE-31-03-201)

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LONG TERM GOALS:

To investigate strategies for coupling global atmospheric models to global ocean models. The ultimate goal is to develop a global coupled numerical prediction system that will provide complete thermodynamic and dynamic, initial and boundary data for the Navy's Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS).

OBJECTIVES:

To determine the causes of the systematic errors of the coupled atmosphere/ocean model. To investigate the interaction and feedbacks between atmospheric heat and momentum forcing and global scale oceanic oscillations and to investigate the limit of predictability of anomalies and oscillations in a coupled global atmosphere/ocean system.

APPROACH:

The research contains both theoretical and modeling components. In the theoretical studies a conceptual analytical model has been built that includes all essential physical processes in the air-sea coupled system. The dynamical framework of this conceptual coupled model will be based on the previous theoretical studies on the seasonal cycle and ENSO mechanisms performed under this research grant. The second part of the research focuses on coupled modeling. The results of several multi-year coupled integrations, performed as part of the international Coupled Model Intercomparison Project (CMIP) will be examined for evidence of proposed feedbacks between atmosphere and the ocean. In addition, coupled data assimilation experiments will be performed with the coupled forecast model.

WORK COMPLETED:

The Navy Operational Global Atmospheric Prediction System (NOGAPS) has been coupled to the Modular Ocean Model (MOM), which is a state-of-the-art dynamic and thermodynamic global ocean model and a global ice prediction model, which is based on the work of Hibler. A flux adjustment scheme has been developed that successfully simulates both the seasonal cycle and interannual variation. Multiple year integrations have been performed with the coupled system and the results compare favorably with the existing climate. The results are part of NRL's participation in CMIP. An NRL review article has been published (Hogan and Li 1997), 2 journal articles have been accepted by the Journal of Atmospheric Sciences (Li 1997a; Li 1997b), and another journal article has been accepted by the Journal of Climate (Li and Hogan 1997).

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RESULTS:

The results of the coupled model experiments clearly demonstrate the importance of correctly predicting the time-mean state for seasonal and interannual variability in the tropics. At the moment a few such systems are being developed, and they have experienced some degree of difficulties. Statistics of eleven coupled general circulation models (GCMs) around the world reveal a common problem in simulating the climatic asymmetry of relevance to the intertropical convergence zones (Mechoso 1994). Some of them produce double ITCZs. A serious problem that has been commonly found is the failure to predict very-thin, low-level marine stratus clouds off the coasts of Americans. These clouds have a fundamental impact on the earth's energy budget (Philander 1996). Some of coupled models were able to reproduce a reasonable interannual variation when forced by the annual mean solar radiation, but they failed when seasonally-varying solar radiation is specified. Other systems simulated well the seasonal cycle, but they poorly simulated interannual variations. With the correct time-mean SST and surface wind, our coupled model system is capable of simulating the observed annual cycle. In addition, the system is capable of simulating the westward propagation of the SST and the wind along the equator, in both the Pacific and Atlantic. The structure of the simulated interannual oscillations resemble those observed during El Nino events.

SYSTEMS APPLICATION:

The Navy is pursuing the goal of coupling atmospheric numerical weather prediction models to ocean prediction models to simulate more accurately at a high resolution the evolution of atmospheric and oceanic circulations at a high resolution. Ultimately, the high resolution prediction must come from a globally re-locatable, mesoscale prediction systems such as COAMPS with an ability to forecast motions down to several kilometers. However, the skill of any mesoscale system is a function of the boundary forcing that drives the forecast model. In addition, since the ocean has a much longer memory than the atmosphere, the initial ocean conditions will play a critical part in the mesoscale coupled model forecasts. This initial and boundary forcing must come from a global prediction system that is capable of accurately predicting the complexities of ocean currents and ocean temperatures.

TRANSITIONS:

Several improvements to the atmospheric component of the coupled model system (NOGAPS) were transitioned to 6.2 for further study. These include improved cloud prediction and improvements to the surface flux parameterization.

RELATED PROJECTS:

This research effort is part of our vertically integrated program for numerical analysis and prediction of the environment. Related 6.1 projects within program element (PE 0601153N) include BE-033-02-4K, BE-033-02-45, 031-03, and 015-08, which include basic research in aerosols, air-sea interactions, boundary layer processes, coastal mesoscale processes, air-ocean coupling, and tropical cyclones. Related advanced development (6.2) projects within PE 0602435N are BE-35-2-20, 035-32, 035-33, BE-35-2-19, 035-71, 035-23, and BE-35-2-32, which focus on the development of data assimilation systems, prediction of aerosols, development of coupled air-ocean-wave prediction systems, and the utilization of massively parallel computer architecture for solution of non-linear prediction systems.

Related 6.4 projects under PE 0603207N include X0513-02, and X0523-01, which focus on the transition of the 6.2 development to operational modeling systems at FNMOC.

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PATENTS:

none